SLSD Lunar Mission Assumptions List Outline
Derived from Constellation Documents and requested HRP DIPT Inputs
Version 2a, August 2008

This is an abbreviated outline of aspects of a lunar mission that are of particular interest to investigators in the Space Life Sciences Directorate (SLSD) and the Human Research Program (HRP).

The information in the list is derived from two sources. The most authoritative source originates from the Constellation Program, either in documents or presentations by or discussions with knowledgeable individuals. The more frequent source is space life scientists, covering information that is not yet available from Constellation due to the developmental state of that Program.

I. Basic Physiological Assumptions
    a. Constellation origin:
        i. None
    b. HRP DIPT Origin:
        i. Assume no beneficial effects of partial gravity exposure compared to 0g
            1. No beneficial effects of partial gravity exposure relative physiological changes observed in free fall conditions
            2. The “linear rate” of bone atrophy as presumed from free fall conditions persists in lunar partial gravity
            3. Weightlessness and partial gravity influence the response of bone cells to countermeasures
            4. 1/6 gravity in and of itself will not provide sufficient physiological stress to fully prevent musculoskeletal and cardiovascular deconditioning in regions which are more susceptible to losses
            5. GI function which affects oral drug absorption: Assume no beneficial effects of partial gravity
            6. Fluid shifts and alteration on cardiovascular output which can affect drug disposition and activity: Assume no beneficial effects from partial gravity
            7. Renal function which affects drug elimination: Assume no beneficial effects of partial gravity
        ii. Assume same deleterious effects of transition from 0g to partial gravity exposure as from 0g to 1g
            1. GI Function which affects drug absorption after oral ingestion: assume same deleterious effects of transition from 0g to partial g as for transition from 0g to 1g

        2. Renal function which affects drug elimination: assume same deleterious effects of transition from 0g to partial g as for transition from 0g to 1g
        3. Assume same deleterious effects of transition from 0g to partial gravity exposure as from 0g to 1g as for transition from 0g to 1g
        4. Fluid shifts and alterations in cardiovascular output which can affect drug disposition and activity: assume same deleterious effects of transition from 0g to partial g as for transition from 0g to 1g
    iii. Other physiological assumptions
        1. Integrated immune flight study complete on ISS:
            a. thus inflight status of immunity understood
            b. any required monitoring strategy has been developed
            c. any necessary countermeasures are validated
        2. assume the risk for crush fractures will be reduced by engineering methods and other technologies
        3. visual acuity and contrast sensitivity are impaired
        4. EVA will sufficiently load the spine to reverse the expansion of intervertebral discs
        5. Neurovestibular and sensorimotor effects
        6. Lung function
        7. Physical fitness
        8. Food absorption
        9. Behavioral studies

II. <u>Mission Ops</u>

Non-EVA Crew Activities:

    i. Constellation Origin
        1. TBD calories and water available for consumption via food delivery equivalent to current available systems (caloric requirements will come from SLSD; food system requirements in HSIR 3.5.1.3.1)
        2. Adequate time, space, equipment available for non-EVA exercise, including exercise of sufficient intensity to prevent physical and psychological deconditioning (rather than only regaining function after deconditioning) and allowing for performance of mission tasks, including strenuous contingency activities, with safety margin (see notes under Vehicle and Habitat Exercise Equipment above) (HSIR 3.5.4.2 and 3.5.4.1.)

    ii. HRP DIPT Origin
        1. Mission Tasks (MTs) during CEV launch phase: emergency egress of launch vehicle, operate controls

during g-load increasing from 1 to 3.4 over 10 minutes, in-flight abort

2. MTs during 2-3 days rendezvous: docking and loiter in LEO
3. MTs during Earth-moon transit CEV phase (out and return phase): operate controls during trans-lunar injection g-load increasing from 0.73 to 1.49 over 315 sec., in-flight maintenance, contingency seat setup while suited, open/close hatch for contingency EVA, contingency EVA tasks, lunar orbit insertion g-load increasing from 0.37 to 0.48 g over 265 sec., and trans-Earth injection g-load increasing from 0.25 to 0.4 g over 474 sec.
4. MTs during CEV-LSAM transfer (and return phase) include: open/close hatch for vehicle transfer, transfer items between CEV and LSAM
5. MTs during Lunar Orbit to surface (LSAM) landing phase: operate controls during g-load increasing from 0.43 to 0.65 g over 399 sec. and during lunar launch phase g-load increasing from 0.52 to 0.65 g over 406 sec., ingress/egress
6. MTs during Lunar Surface (IVA) phase: open/close hatch, squat to lift/carry heavy and light objects, ladder/ramp climb and descend, trip/stumble with recovery, fall to side impacting hip, EVA don/doff, connect umbilicals to suite
7. MTs during Re-entry and landing CEV phase: operate controls during two bouts of deceleration, with g loads increasing from 0 to 6-8 g over 5 minutes, followed by 15 min. at 0 g, and another exposure increasing from 0 to 4.8 g over 10 min, unassisted post-landing egress scenarios (nominal and off-nominal; multiple CEV orientations; release from loaded restraint system); crewmember rescue hatch egress (assisted egress)(multiple CEV orientations; release from loaded restraint system)
8. MTs during Re-entry and landing CEV phase: raft ingress/water survival
9. Task performance will be designed to minimize herniated disc risk
10. Physiological testing during mission will document and ensure adequate fitness

EVA Operations, All Increments:

i. Constellation Origin

1. Sortie type mission (up to 7 days) will have all 4 crewmembers doing EVA most days ESAS 4.3.7.1)

2. Outpost-type mission
    a. Alternating 2 person team EVAs on most days (so each person 5 EVAs within a 2 week period) (ESAS 4.3.9)
    b. "Up to three 8-hour EVAs per person per week" (*Gernhardt, "Extravehicular Activities (EVA) and Pressurized Rovers," ESMD Lunar Architecture Update, AIAA Space 2007, 20 Sep. 2007.)*
3. Average length of single EVA about 8 hours (including egress/ingress) *(Gernhardt, "Extravehicular Activities (EVA) and Pressurized Rovers," ESMD Lunar Architecture Update, AIAA Space 2007, 20 Sep. 2007.)*
4. Adequate calories during EVA will be available via food delivery system equivalent to current system (HSIR 3.5.1.3.2 says 3035 kcal/day; EVA SRD requirement's 2046-2048 for ability to eat during EVA*)*

ii. HRP DIPT Origin

1. MTs during Lunar Surface (EVA) phase: EVA suit don/doff; EVA 10K walk back; incapacitated crew member rescue, squat to lift/carry heavy (about 80 kg. mass) object; ladder/ramp climb and descend; shovel rocks/soil; hammer; habitat assembly/deployment tasks for Lunar/Mars habitat; In-situ Resource Utilization (ISRU) deployment; vehicle/rover contingency operations; EVA tool usage--handgrip/forearm and whole are specific tasks that are repetitive and fatiguing; complete surface EVA session including multiple tasks (endurance requirement); trip/stumble with recovery; fall to side impacting hip
2. Radiation shielding will be available within 2 hours or about a 10 km walk during any operations